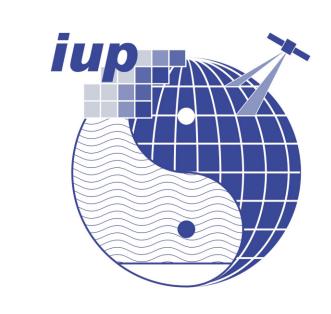
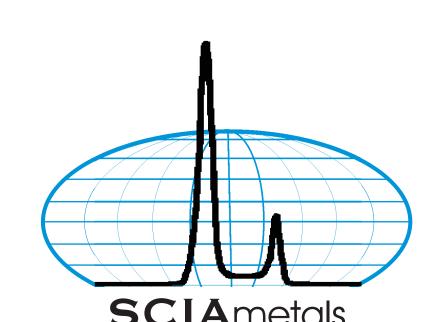
# SCIAMACHY limb measurements of mesospheric airglow





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#### Introduction

**SCIAMACHY** limb scans routinely extend into the mesosphere to altitudes of up to 92 km. A number of emission signals throughout the SCIAMACHY spectral range from 214 nm to 2.17 µm are observed.

In the UV region, band emissions of NO and OH are observed as well as line emissions of metallic species like e.g. Mg, Fe, Na, Si and their ionized counterparts. These emissions are mainly due to resonance fluorescence.

In the near-IR region, emissions from the  $^{1}\Delta$  (1.27  $\mu$ m) and  $^{1}\Sigma$  (760 nm) bands of  $O_2$  are observed. Those excited states are due to photolysis of ozone in the Hartley-Huggins bands, and can be used to derive ozone number densities if steady-state is assumed for  $O_2(^{1}\Delta)$ .

An optimal estimation retrieval of NO and Mg/Mg<sup>†</sup> assuming resonance fluorescence has been developed, and first results of altitude profiles as well as global distributions are presented.

#### Optimal Estimation

The Optimal Estimation (Rodgers, 2002) method was applied to SCIAMACHY limb data to simultaneously retrieve altitude profiles ozone, NO and singly ionized Mg densities as well as total air density. The strong ozone absorption in the UV limits the altitude range to altitudes above  $\sim 70$  km. Due to low pressures in the mesosphere region , quenching is negligible. Self-absorption of Mg $^{\dagger}$  and NO is considered as well as backscattered solar radiation.

# Mesospheric OH

In the middle atmospere OH is produced by **photolysis of water** in the UV region as well as oxidation of water, hydrogen and methane. The A(0)-X(0) transition of OH at 308 nm is observed in the SCIAMACHY limb measurements.

The signal is most prominent in the middle mesosphere between 80 and 70 km, where the solar UV flux as well as the supply of water and methane from lower altitudes are sufficiently high.

A retrieval of OH for these emissions using HITRAN data is currently being developed.

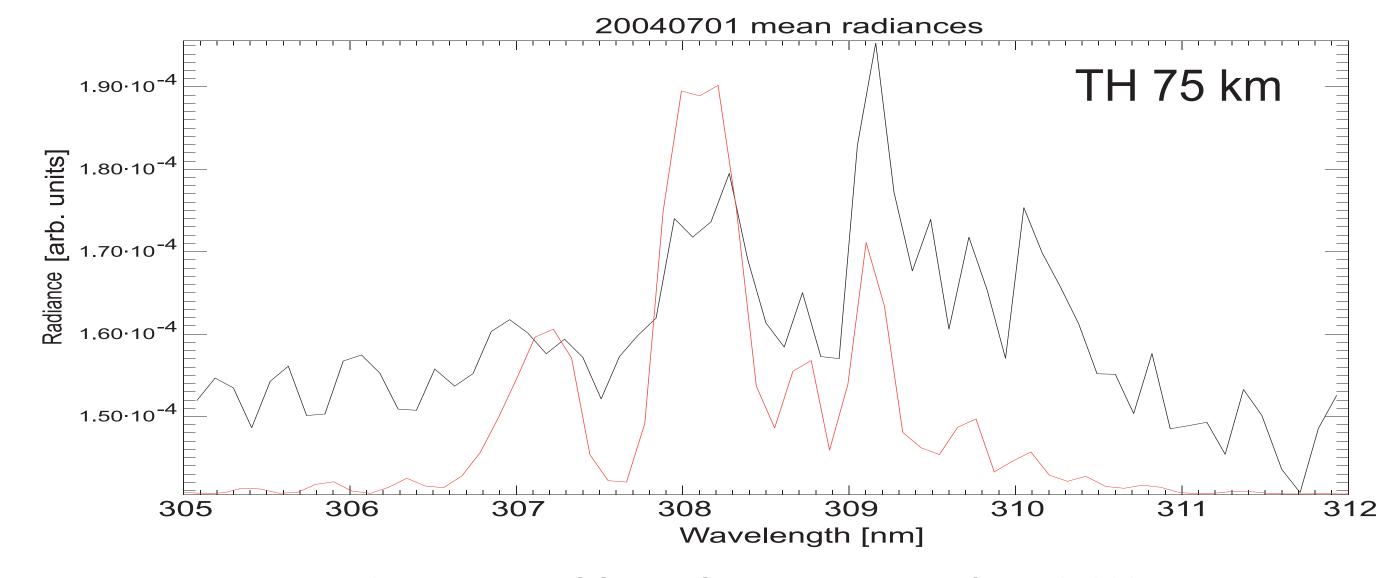


Figure 1: Normalised SCIAMACHY limb spectra of July 1, 2004.

Presented are average radiances around 308 nm of 209 limb profiles.

Red: Synthetic emission spectrum of X(0)-A(0) transition, based on HITRAN data

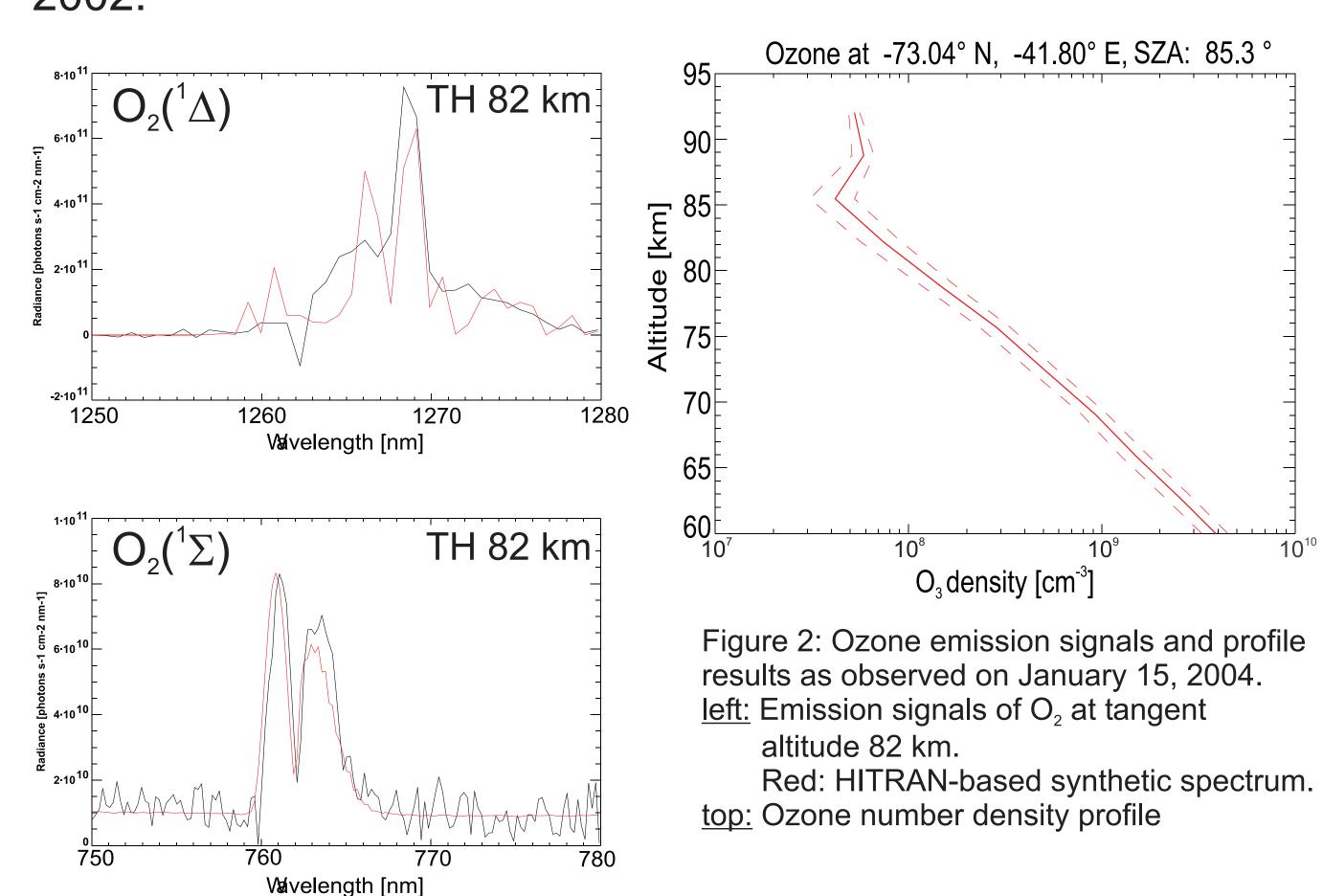
## Mesospheric O<sub>3</sub>

First preliminary results of SCIAMACHY ozone retrievals from the excited-state O<sub>2</sub> emissions are presented here.

In a first step, the number densities of  $O_2(^1\Delta)$  and  $O_2(^1\Sigma)$  were retrieved from the 0-0 transitions using HITRAN spectral data. Then ozone is calculated considering photochemical equilibrium of  $O_2(^1\Delta)$ , considering the following reactions:

- Photolysis of ozone
- emission from  $O_2(^1\Delta)$   $O_2(ground)$
- emission from  $O_2(^1\Sigma)$   $O_2(ground)$
- quenching of  $O_2(^1\Sigma)$  and  $O_2(^1\Delta)$ .

Reaction rates are the same as used in Khabibrakhmanov et al, 2002.



### Metal species

Metal species like Mg, Fe, Si, Na and others enter the Earth's atmosphere by ablation from cosmic dust and meteorites. This ablation occurs mainly in the upper mesophere at altitudes of 80 to 120 km.

SCIAMACHY routinely covers the altitude range from the surface up to 92 km. Thus, limb spectra of SCIAMACHY exhibit emission signals from the above species as well as from their ionized counterparts.

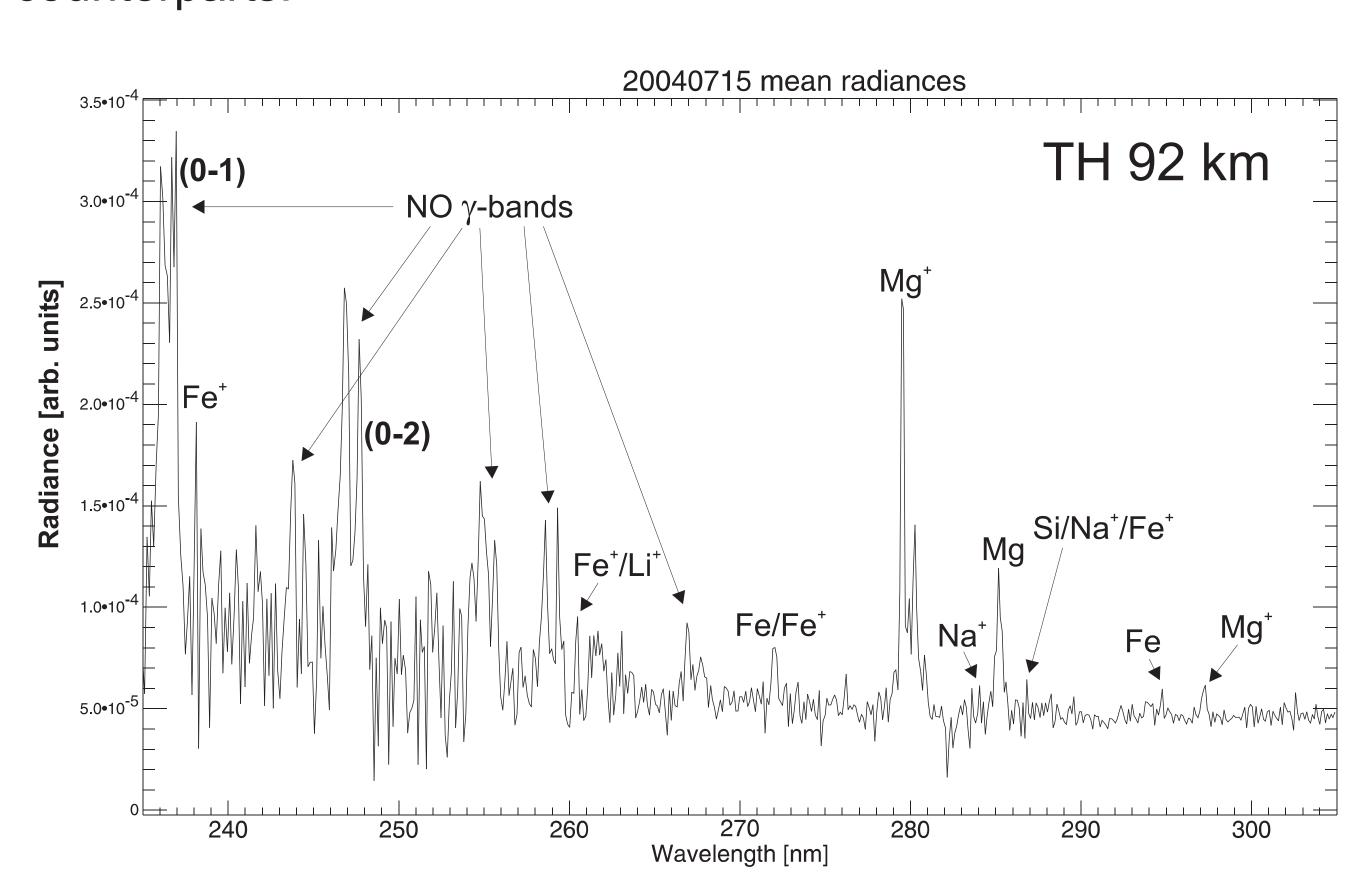


Figure 2: Emission signals in SCIAMACHY channel 1, tangent altitude 92 km, radiances normalised by solar spectrum

The NO bands can clearly be observed as well as several signals from metal species.

We present the first near-global measurements of singly ionized mesospheric Magnesium. The emission signal observed around 280 nm is due to resonance fluorescence. An optimal estimation retrieval has been carried out to obtain global composite average values of Mg<sup>+</sup>.

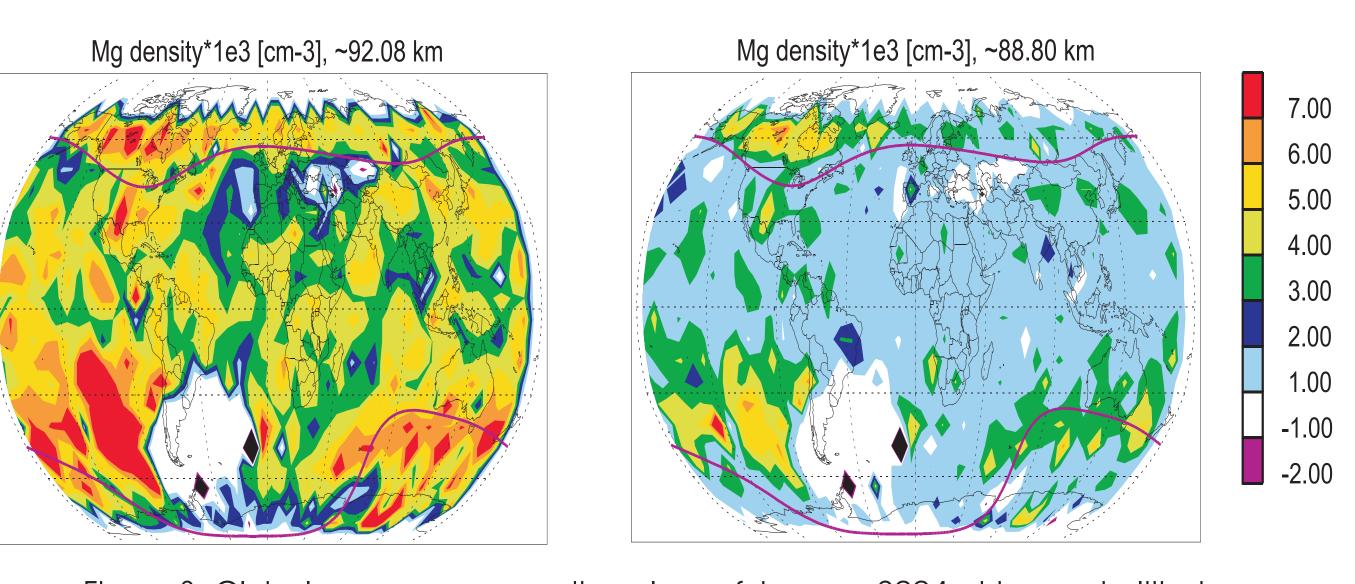


Figure 3: Global average composite values of January 2004 at tangent altitudes 88.8 and 92.1 km. Purple lines denote 60° geomagnetic latitude.

Increased values of Mg+ occur in the nothern as well as in the southern auroral oval regions. The region of the Southern Atlantic Anomaly (SAA) is taken out because of bad data quality. High values west of South America might be due to outflow from the SAA.

This is a rather expected behaviour for an ionized species since ionization is increased in auroral regions due to impact of high-energetic particles.

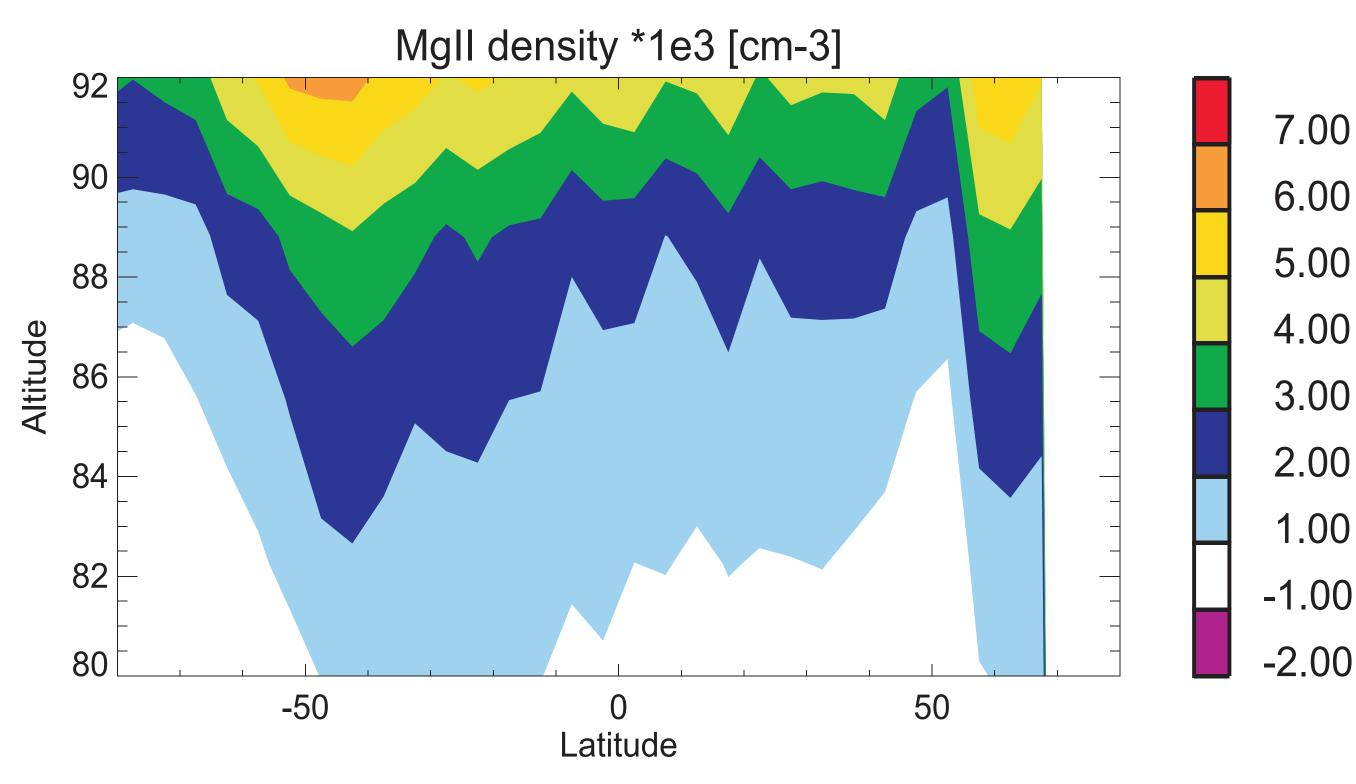


Figure 4: Latitudinal cross sections of Mg+ number densities as observed in January 2004.

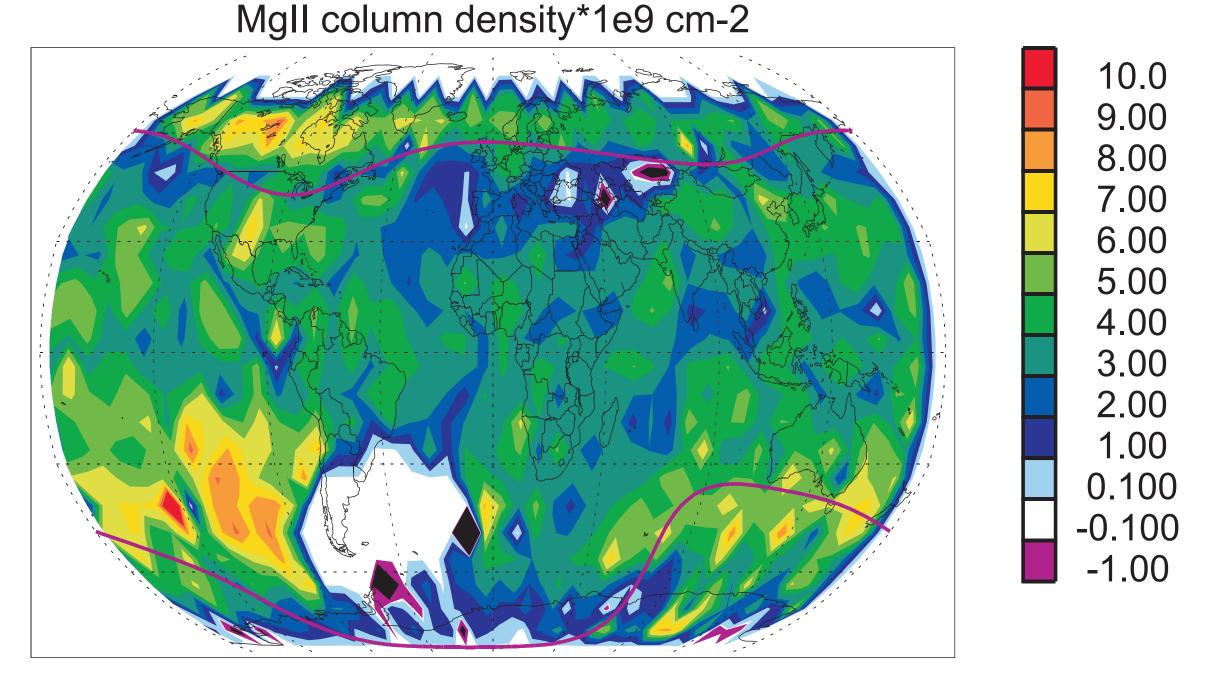


Figure 5: Column densities of Mg+ as observed in January 2004.

The measured column densities agree well with total column values observed at

- Wallops Island, U.S.A (36.9° N, 75.5° W): 1.7\*10¹¹ cm⁻²
   (Zbinden et al. 1975)
  - Sardinia, Italy (36.2° N, 9.0° E): 2.1\*10° cm<sup>-2</sup> (Herrmann et al. 1978)

# Mesospheric NO

NO number densities have been retrieved from the 0-2  $\gamma$ -band emission around 245 nm. The 0-2 transition hs been chosen for the retrieval because it still has a sufficient high S/N, but is much less affected by self-absorption than the stronger 0-1 and 0-0 band.

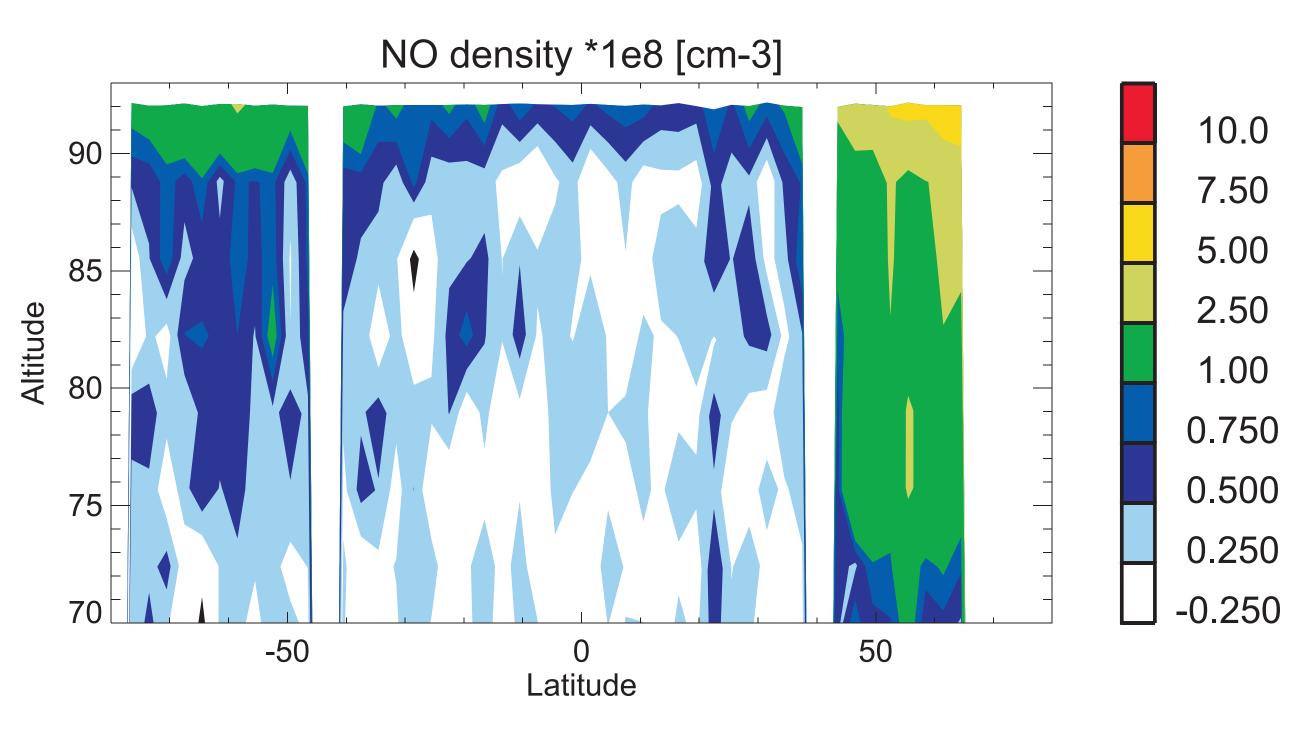


Figure 6: Latitudinal cross sections of mesopheric NO as observed on January 11, 2004.

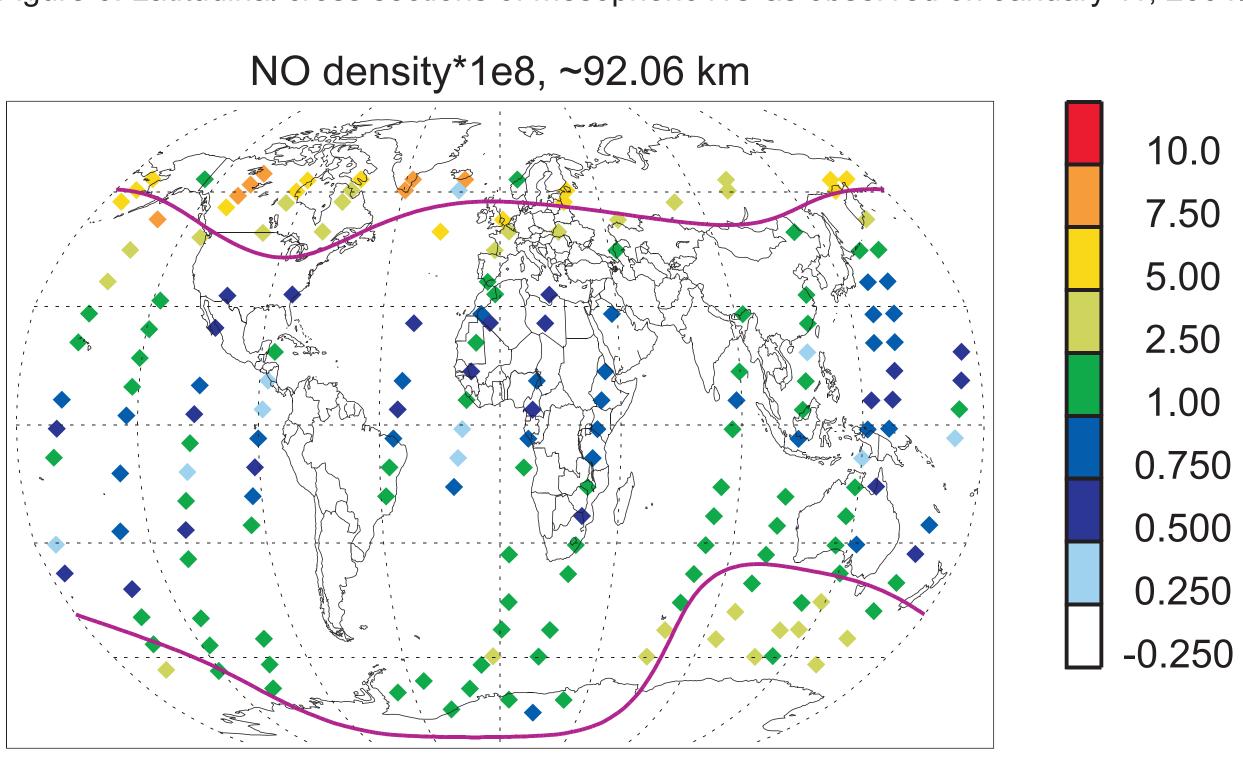


Figure 7: NO number densities at tangent altitude 92 km as observed on January 11, 2004.

Increased NO number densities occur in the northern auroral oval regions. The southern auroral region is less pronounced, but still visible.

Enhanced values of NO in the nother sub-polar region below 80km might be due to the October/November 2003 solar proton event and subsequent high geomagnetic activity.

#### Conclusions

- SCIAMACHY limb spectra exhibit airglow emissions of numerous mesospheric species.
- OH and O<sub>2</sub> emissions can be observed in the spectra. The latter are used to retrieve number densities of mesospheric ozone. A OH retrieval is under development.
- NO number densities are retrieved from the 0-2 band emission. Enhanced number densities are observed in regions of increased geomagnetic activity.
- Mesospheric Mg+ is retrieved from resonance fluorescence emission signals around 280 nm. In general, number densities are increasing with altitude, notably enhanced values occur in the auroral regions as well as westward of the SAA.

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